Image fusion of LF-MRI and MRA for endovascular interventions

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Synopsis

Peripheral arterial occlusive disease can be treated with endovascular interventions. These interventions are currently intraoperatively guided by fluoroscopy. A possible alternative is LF-MRI, but the current image quality of low-field (LF) MRI may not be sufficient. The purpose of this study is to evaluate the possibility of image fusion of LF-MRI with preoperative MRA to improve the image quality. To test this, LF-MRI and 3T MRI images were made of a healthy test subject. These images were registrated using manual landmark detection. The result was a visually successful registration image of LF-MRI and anatomical MRI, which shows the possibility of manual image registration.

Introduction

Peripheral arterial occlusive disease (POAD) can be treated with endovascular interventions. Currently, these interventions can be guided with intraoperative fluoroscopy, possibly fused with the preoperative MR or CT angiography.[1] A downside of fluoroscopy is the use of ionizing radiation and iodinated contrast. A possible alternative to fluoroscopy is low-field (LF) MRI (<0.5 tesla) which, unlike the most common MRI systems typically has an open bore configuration so the patient stays accessible. However, the image quality and temporal resolution of LF-MRI may not be sufficient for guiding endovascular procedures without additional information. Therefore, the purpose of this study is to evaluate the possibility of image fusion of LF-MRI with a preoperative diagnostic scan (e.g. MR angiography) to make this guidance feasible.

Methods

A healthy male test subject (26 years) was imaged on a 3T system (Siemens MAGNETOM Skyra, Erlangen, Germany) and an LF-MRI 0.25T system (Esaote G-scan Brio, Genoa, Italy). On the 3T system, we imaged the area from aortic bifurcation to the popliteal artery with a T2-weighted TRUFI sequence and a non contrast enhanced MR angiography sequence in which, the contrast is based on the difference of signal intensity between slow flow and fast flow (NATIVE SPACE)[2]. On the LF-MRI we used a 3D bSSFP sequence. The LF images were made in two areas: the region of the iliac arteries and the region of the femoral arteries. For the image registration Mimics Research 20.0 (Materialise) was used. Anatomical landmarks (for iliac region: bifurcations of iliac arteries and lumbosacral joint, for femoral region: bifurcations of femoral arteries and femoral head) were manually selected in both the 3T and 0.25T images (shown in Figure 1). Displacement between the combined images were manually measured in a DICOM viewer to validate the registration. The residual error at the bottom of fourth lumbar vertebra was measured in three different registrations of the same images (example shown in Figure 2).

Results

Figure 3 portrays the result of a manual registration of the 3T images combined with LF-images. The displacement in the three registrations was respectively: 2 mm, 1.8 mm and 1.2 mm. Visual inspection shows a better alignment in the center of the LF-MRI than at the borders of the image.

Discussion

The results of this study show the potential of image fusion of LF-MRI with a preoperative scan. The change in displacement between different registrations is probably caused by the manual selection procedure, which is difficult to reproduce and time-consuming. Automatic landmark detection could make the process of registration faster, but might be challenging for the LF-MRI images. As the registration is now performed with landmarks mostly in the center of images, the alignment is reduced on the borders. A higher number of landmarks could improve this alignment. Since the vessels are most important for the guidance of endovascular procedures, landmark selection is now performed on the bifurcations of the vessels making the registration less prone to misregistration in that area. Although image registration might solve the issue of spatial resolution, temporal resolution of LF-MRI (2 images per second) is still much lower than that of fluoroscopy (30 images per second)[3], so the amount of images that can be generated during interventions will be drastically reduced. In this study we only registered anatomical images, but the estimated transformations should also be applied to combine LF-MRI with MRA images to provide a high quality roadmap for the surgeon during an interventional procedure. This is possible with our data since the MRA is reconstructed from two anatomical images, otherwise small patient movement would lead to inaccuracy.

Conclusion

Manual image registration is possible for LF-MRI with a preoperative MRI of high quality, which is a first step for the use of LF-MRI for guidance of endovascular interventions.

Acknowledgements

No acknowledgement found.

References

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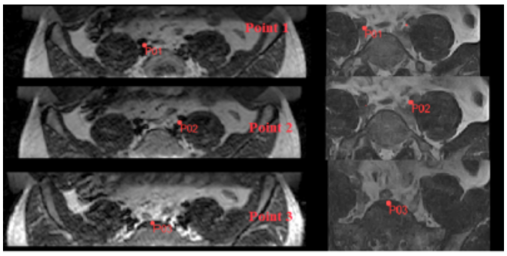
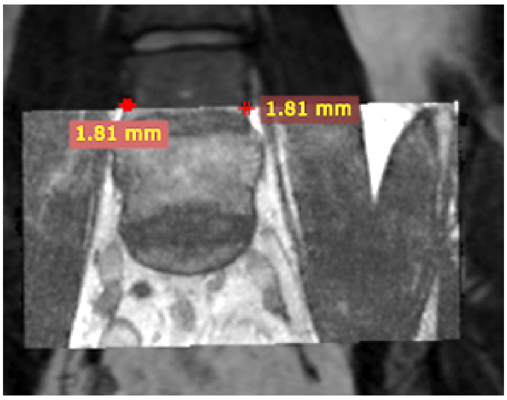
Figures



Selected anatomical landmarks in transverse views, left column shows the 3T images and right column the LF images. P01: Bifurcation of right iliac artery. P02: Bifurcation of left iliac artery. P3: Lumbosacral joint.



Manual measurement of the residual displacement after registration.

Result of the registration, two LF-MRI scans placed over the 3T image. The red arrow shows a clear example of residual displacement at the border.